0.1 Markov Model

0.1.1 NCX Channel Inactivation Model

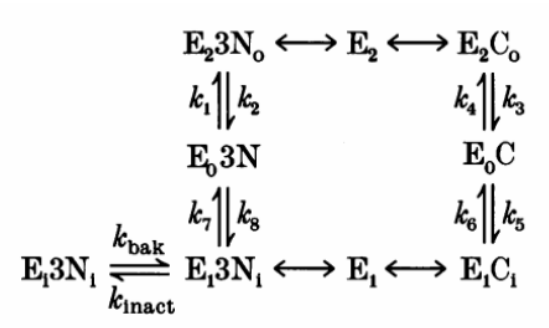

Figure 1: NCX Ion Channel Model

Notations

- E_1 : States with binding sites oriented to the cytoplasmic sides
- E_2 : States with binding sites oriented to the extra-cellular sides
- $E_1 3N_i$: States with binding sites oriented to the cytoplasmic sides containing 3 Na+ ions
- $E_0 3N$: States with binding sites occluded with 3 Na+ ions
- $E_2 3N_0$: States with binding sites oriented to the extra cellular sides with 3 Na+ ions
- $E_1 C_1$: States with binding sites oriented to the cytoplasmic sides containing 1 Ca++ ion
- $E_0 C$: States with binding sites occluded with 1 Ca++ ion
- $E_2 C_0$: States with binding sites oriented to the extra cellular sides with 1 Ca++ ion

Simultaneous Diff Equation

$$\frac{d(E_2 3N_o)}{dt} = k_1(E_0 3N) - k_2(E_2 3N_o)$$
$$\frac{d(E_0 3N)}{dt} = k_7(E_1 3N_i) + k_2(E_2 3N_o) - (k_1 + k_8)(E_0 3N)$$
$$\frac{d(E_1 3N_i)}{dt} = k_{bak}(E_i 3N_i) + k_8(E_o 3N) - (k_{inact} + k_7)(E_1 3N_i)$$
$$\frac{d(E_i 3Ni)}{dt} = k_{inact}(E_1 3N_i) - k_{bak}(E_i 3N_i)$$
$$\frac{d(E_2 C_o)}{dt} = k_4(E_o C) - k_3(E_2 C_o)$$
$$\frac{d(EoC)}{dt} = k_3(E_2 Co) + k_6(E_1 C_i) - (k_4 + k_5)(E_o C)$$
$$\frac{d(E_1 C_i)}{dt} = k_5(E_o C) - k_6(E_1 C_i)$$

Summed Version

$$\frac{d(E_1)}{dt} = k_{bak}(E_i 3N_i) + k_8(E_o 3N) + k_5(E_o C) - (k_{inact} + k_7 + k_6)(E_1)$$
$$\frac{d(E_0 3N)}{dt} = k_7(E_1) + k_2(E_2) - (k_1 + k_8)(E_o 3N)$$
$$\frac{d(EoC)}{dt} = k_3(E_2) + k_6(E_1) - (k_4 + k_5)(E_o C)$$
$$\frac{d(E_2)}{dt} = k_1(E_o 3N) + k_4(E_o C) - (k_2 + k_3)E_2$$
$$\frac{d(E_i 3N_i)}{dt} = k_{inact}(E_1) - k_{bak} E_i 3N_i$$
$$E_i 3N_i = 1 - E_1 - E_2 - E_o C - E_o 3N$$

Reduced Equation

$$\frac{d(E_1)}{dt} = k_{bak} - k_{bak}E_2 + (k_8 - k_{bak})(E_o 3N) + (k_5 - k_{bak})(E_o C) - (k_{bak} + k_{inact} + k_7 + k_6)(E_1)$$
$$\frac{d(E_0 3N)}{dt} = k_7(E_1) + k_2(E_2) - (k_1 + k_8)(E_o 3N)$$
$$\frac{d(EoC)}{dt} = k_3(E_2) + k_6(E_1) - (k_4 + k_5)(E_o C)$$
$$\frac{d(E_2)}{dt} = k_1(E_o 3N) + k_4(E_o C) - (k_2 + k_3)E_2$$

Constants

- Gamma : $\gamma = 0.02$
- Membrane Potential : $Em = ...$
- Kem : $Kem = exp(0.5 \times (1 - \gamma) \times Em \times \frac{F}{RT}) = ...$
- Rate Constan : $k_1 = 10^4 \times Kem$
- Rate Constan : $k_2 = F_{3no} \times \frac{10^4}{Kem}$
- Rate Constan : $k_3 = F_{co} \times 5.17 \times 10^4 \times Kem$
- Rate Constan : $k_4 = 5.17 \times 10^4$
- Rate Constan : $k_5 = 5.17 \times 10^4$
- Rate Constan : $k_6 = F_{ci} \times 5.17 \times 10^4$
- Rate Constan : $k_7 = F_{3ni} \times 1.84 \times 10^4$
- Rate Constan : $k_8 = 1.84 \times 10^4 \times$
- Rate Constan : $k_{bak} = 0.12$
- Rate Constan : $k_{in} = 0.8$